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REVIEW OF V. A. VENIKOV'S BOOK "APPLICATION OF THE THEORY OF SIMILARITY AND PHYSICAL MODELING IN ELECTRICAL ENGINEERING"

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/In Elektrichestvo, No 1, 1952, it was announced that V. A. Venikov was awarded the 1951 P. N. Yablochkov Prize of 20,000 rubles for this book. The 168-page book was published by Gosenergoizdat in 1949. Its sales price is 9 rubles./

The author's aim was to fill the gap that exists in technical literature on the application of the theory of similarity and physical modeling to electrical engineering problems. As the result of the efforts of Soviet scientists headed by Academician M. V. Kirpichev, the theory of similarity and physical modeling have found wide application in many branches of thermal engineering, hydraulics, and hydromechanics. Thus, the theory of similarity and the general scientific basis of physical modeling are quite well known to many specialists in these fields. At the same time, however, the application of this theory in electrical engineering has been delayed despite the introduction of methods of physical modeling, because relatively little on the theory has been published in electrical-engineering literature. In most cases, individual electrical engineers who have attempted to model a certain phenomenon have made use of special considerations. A few works which described the general principles of the theory of similarity and physical modeling (e.g., the candidate's dissertation of V. V. Naumov, 1943 - 1944) have not been published.

A brief statement of the theory of similarity was given in L. I. Gutenmakher's book Electrical Models, but a more detailed account is found in this book. It should be noted that these books are fundamentally different in content and thus serve to supplement each other. Gutenmakher's book deals with problems of mathematical modeling, while this book is concerned with physical modeling, based on the theory of similarity.

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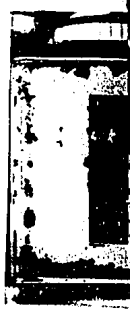


Without belittling mathematical modeling, it must be noted that in certain cases, physical modeling is an indispensable tool for the scientific and technical study of phenomena occurring in electrical equipment. This refers, for example, to the study of the lightning protection of electric power substations and the investigation of stability and transients in complex electric power systems. In these and similar cases, the study of phenomena by mathematical methods, even if the most modern calculating methods are used, will of necessity be based on certain assumptions which often cannot be checked in practice. But a well-designed and carefully checked physical model of a complex system can be a very reliable tool for research; it is also a graphic demonstration which any engineer can understand.

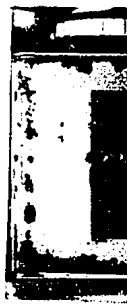
The book is composed of a foreword, introduction, five chapters of text (148 pages), and appendices. The appendices include tables of dimensions and similarity criteria, a list of symbols, a bibliography, and a topical index. There are over 60 illustrations.

Chapter I is devoted to the general and basic concepts of geometrical, physical, and mathematical similarity, and of physical and mathematical modeling. Chapter II contains a description of general methods of determining similarity criteria. Chapter III offers determinations of similarity criteria for particular cases of modeling. Chapters IV and V, comprising a total of 70 pages, i.e., nearly half the text, is devoted to the principles of "dynamic modeling of electric power systems." The term dynamic modeling is used as a synonym for physical modeling and serves to emphasize the difference between models of electric systems using rotating machines and the so-called network models in which the electric machines are replaced by equivalent resistances and inductances. Chapter IV contains a description of general principles of modeling electric power systems, and Chapter V, an account of the components of an actual model designed by the author.

The reader thus finds sufficient material to acquaint himself with the principles, and partially with the details, of the problem of using physical modeling in the various branches of electrical engineering. Unfortunately, in view of the very modest size of the book, the author was compelled to deal only briefly with many aspects of modeling. This may be an explanation for the tenor of hurry and the occasional superficiality of the descriptions in certain sections of the book. For example, the heading of Section e, Paragraph 2, of Chapter III promises a consideration of wave processes in induction motors. We find, however, merely a partial example of the calculation of the input frequency characteristic. Likewise, the reader will scarcely be satisfied with the somewhat garbled account of modeling gas-discharge processes (pp 63-65).

Several points are rather difficult [illegible] while a number of inaccuracies hardly contribute to the popularity of the topic. For example, on page 64, it is stated current density is "inversely proportional to the square of the linear dimensions," and later, that the current density "is inversely proportional to the linear dimensions." The absence of any restrictions seems to indicate that the author is attempting to generalize his conclusions for any type of gas discharge, which in our opinion is not well-founded. This refers in particular to phenomena in which quantum processes, which do not conform to macroscopic similarity criteria, play an important part. The author's explanation of the discrepency between experiment and the results of the theory of similarity as applied to the gas discharge is not entirely convincing.

Returning to the general evaluation of the book, its minor inaccuracies do not seriously reduce its over-all worth. The principal book's shortcomings are of a didactic and, to some extent, methodological nature. The large number of footnotes containing supplementary explanations of the text cannot be considered an asset to the presentation of the basic material; it seems that the incompleteness



and inaccuracy in the text required the corrections and additions in the footnotes. For example, the definitions of some terms may be found only in the notes, despite the fact that the author uses the terms in the body of the text. This category includes the definitions of scales and integral analogs (page 37).

The statement of the basic concepts of the theory of similarity is also poor from the didactic standpoint. In fact, the theorems of similarity which unavoidably involved the concepts of similarity criteria were stated in Chapter I (paragraph 5); however, the criteria had not been explained clearly at this point, since the definition given earlier is quite abstract and formal. Immediately following this formal definition, the author begins to use the concept of similarity criteria which, for lack of illustration by a concrete example, must prove quite puzzling to the reader.

Despite the abundance of footnotes, the author, in general, has not made the basic text completely understandable for the reader. For example, Figure 3 on page 12 was meant to illustrate the concepts of mathematic modeling but fails to do so because of the absence of an adequate explanation, and an ordinary cross section of a cable in Figure 3a is referred to as "temperature distribution in the cable." A table on page 20, which bears the heading, "Similarity in Electrical Engineering," is an attempt to classify systems to which the theory of similarity is applicable. This table, too, has no introduction or explanation. Without analyzing the table in detail, we note, as an example, that similarity of wave processes, which was placed in the electrical circuits group in the table, appears more properly to belong to the group of electric and magnetic fields.

Inaccurate and incomplete statements are found in the book. Let us examine some of them. On page 25, it is said that a physical equation cannot depend on the way in which it is represented. This statement is not accurate because the form of the equation may change very substantially with the choice of the coordinate system. On page 36, it is stated that when ϕ (a, x, y) has the form ln axy and sin axy, a transformation of the type shown in Chapter II (paragraph 19) is impossible. The reader may well ask what will be true if ϕ (a x y) has the form $\ln^2$ axy, for example.

The assertion on page 37 that "all things considered, the engineer is generally interested only in the relative values of the quantities characterizing the behavior of a process," is open to argument. On page 44, we find the statement that "if equations describing the behavior of two processes - providing the basic units are properly selected - have identical numerical coefficients, these processes are completely identical." It should be explained that the processes are not identical but similar; only the latter statement can be proven.

Another inaccuracy is found in the description on pages 103-104 of a bearing design which supposedly reduces friction to very small values, i.e., practically eliminates it. The author is, of course, not referring to the elimination of friction but only to relieving the generator shaft of the friction forces by supplying from an auxiliary motor the power necessary to overcome them. In discussing a practical example of the application of a standard low-power machine for modeling purposes (pages 130-131), the author limits himself, without reservations, to a comparison of the original and the model only with respect to the parameters x_d, x_q, x_e, R, T_o, M_o; the sufficient conditions for similarity, however, require also that the parameters x'_d and x_d'' be considered. On page 132, in discussing the modeling of phenomena connected with static stability, the author, again without reservations, writes a system of equations characteristic only of positional systems. Unfortunately, these are not the only cases of incomplete presentations in the book.

As to the methodological structure of the book, it should be noted that even a rough evaluation of the accuracy of physical modeling, primarily for electric power systems, is missing. Such an evaluation would be desirable for establishing the limits of applicability of this research method. In addition, nothing was said as to the possibility of simultaneous modeling of thermal and electromagnetic processes in electric machines.

On the other hand, there is no real need for a separate description of the problem of modeling transformers and DC and AC machines, using the theory of similarity; the general theory of modeling of all electric machines, including transformers, might have been based on some general system of equations. However, the system used by the author consists of a separate analysis of the conditions of similarity of electric machines and has the advantage of being easier to understand.

In summarizing, it may be stated that the book under review, even with its minor defects of presentation, contains valuable material for engineers and scientific workers desiring to acquaint themselves with problems of the theory and practice of physical modeling. Of particular value is the description of the design and circuits of components in a model made by the author. This work is a major contribution to the technique of scientific and experimental research on complex engineering problems in the field of electric power engineering. Notwithstanding its defects, Venikov's book can be recommended to engineers and scientists working in the electric power engineering field.

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